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Plant Diseases; Potato Spraying.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 142: PLANT DISEASES; POTATO SPRAYING

L. R. Jones and N. J. Giddings

SUMMARY

I. Plant Diseases of 1908.

The season being exceptionally dry insect injuries and physiological maladies were particularly prevalent. The flea beetle, tipburn, and early blight were especially troublesome; while late blight was absent and scab not as serious as usual. Bordeaux proved efficaceous in all cases, repelling flea beetles and lessening tip burn and early blight injuries. Several minor attacks of leaf blotch and black leg of the potato, of apple, pear and plum scabs, of apple and blackberry rust, fire blights etc., were observed.

II. Potato spraying experiments of 1908.

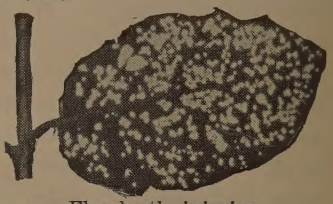
Bordeaux mixtures and lime-sulphur were used to combat fungus injuries. The lime sulphur plots gave a 37 percent larger yield than did the unsprayed plots, while bordeaux twice applied yielded 67 percent more and that applied four times 141 percent more than did the unsprayed plots.

Eighteen years of bordeaux usage at the Station emphasise its value. The lowest gain has been 26 percent, the highest 215 percent, the average 92 percent.

I. Plant Diseases of 1908

The season of 1908 was an extremely dry one. Rarely has so droughty a summer been known in New England. Forest fires, dried up springs and wells, parched pastures, short hay crops and discouraged farmers were common. One good outcome, however, came to pass; for as a result most of the diseases due to vegetable parasites were held in check. Certain other maladies which are primarily due to insects or to physiological disturbances of the affected plant were at the same time aggravated.

POTATO DISEASES



Flea beetle injuries.

Insect injuries. Dry weather tends to aggravate insect injuries. It favors the development and activity of the pests and so checks the growth of the plants that they do not recover promptly from the injuries thus inflicted. The usual activities of the colorado beetle began to be evident in June. As explained on page 114, the lime-sulphur spray proved ineffective against this beetle and arsenites had to be used in addition to protect the plants on the plots where this remedy was being tried. The flea beetles were unusually abundant from mid-summer onwards, and caused much damage on all the potato plots except those sprayed with bordeaux mixture.

Tip-burn. This malady, being due to dry heat in conjunction with any other unfavorable conditions, was especially in evidence in 1908. Many potato growers who complained that their crops were attacked by early blight were really suffering from this trouble. Such a season offered an exceptionally good opportunity for determining the efficiency of bordeaux and other spray mixtures in preventing tip-burn. Experiments with this particular point in view were undertaken with results as reported on page 113. These trials give conclusive evidence as to the value of bordeaux mixture in reducing tip-burn.

The appearance of the leaves when affected by this malady is well indicated by the cut on page 110. It is so common for potato growers in dry seasons to confuse this malady with blight that it were worth while to learn to discriminate. Yet since bordeaux is a specific in any event, the importance of a careful diagnosis is not economically important.

Early blight. The early blight fungus, *Alternaria solani,* caused a considerable amount of damage in some potato fields in 1908. In general, however, the loss was not great except on the weaker plants where the attacks of this fungus were followed by tip-burn. In combination these incursions serve to reduce the vigor and to shorten the life of unprotected plants. Spraying with bordeaux mixture checks the fungus[1] and also lessens the tip-burn.

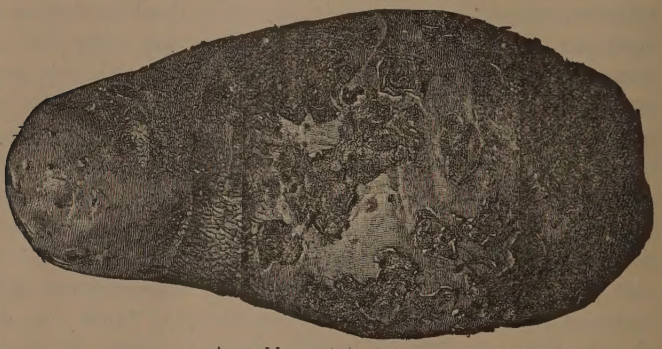
The appearance of leaves affected by this malady in its earlier stages is pictured on page 111.

Late blight. This disease, due to the fungus *Phytophthora infestans,* was not found in the potato fields about Burlington in 1908, nor was it reported to the Station from any other place in Vermont. It was not very general in its occurrence in this state in 1907 and evidently its non-appearance in 1908 is to be attributed to this fact, coupled with the unusually dry weather. This was a general experience throughout North America. In connection with the special studies of this fungus at this Station requests were made in the autumn of 1908 for specimens of potato tubers showing the dry rot caused by this fungus. None was obtainable from the following Experiment stations: California, Colorado, Connecticut (New Haven), North Dakota, Florida, Delaware, Illinois, Indiana, Kentucky, Iowa, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, New York (Geneva and Ithaca), Nevada, Pennsylvania, Rhode Island, Texas, Wisconsin, Wyoming, Porto Rico, Ottawa, (Canada). Specimens were received through the courtesy of the Experiment stations from Storrs, Conn., and Wooster, Ohio, and through the officers of the Bureau of Plant Industry from

[1] See Vt. Sta. Rpt. 18, p. 275 (1905).

Louisburg, Pa. In addition specimens were secured from Germany, Holland, Ireland and Scotland, which is of interest incidentally as showing how much more prevalent the malady was in European countries than in America. In view of the general suppression of the late blight in America in 1908 it does not seem probable that there will be any epidemic of it during the coming summer, 1909. However the conditions determining the recurrence of this malady are not sufficiently well understood to justify any confident prophecy, and growers should not relax vigilance on this account.

Potato leaf blotch. This is a fungus trouble (*Cercospora concors*) of minor importance resembling early blight in certain respects. It was again found in one of the same gardens where it has been observed the two preceding seasons. It seems clear, therefore, that it persists where once established. There was, however, less of it than two years ago and there seems no reason for serious practical concern about it.



A scabby potato tuber.

Potato scab. The tuber disease attributed to the fungus *Oospora scabies* was not so troublesome as usual last year. Part of the experimental plots were located on badly infected soil where in the moister season of 1907 the tubers were practically worthless because of scab. They were badly attacked again in 1908

but less severely than in 1907. Regardless of the season avoidance of infected soil is essential for a clean crop. While seed disinfection is effective only where clean soil is planted, it is, nevertheless, a safe precaution in all doubtful cases. Our practice is, therefore, to soak the seed tubers two hours in a disinfecting solution of 1 pound of formalin in 30 gallons of water. This is best done some days in advance of planting, spreading the tubers after disinfection in a thin layer on the grass or barn floor to favor prompt drying.

Black-leg of the potato. This malady is characterized by a rotting of the base of the potato stem, principally below ground. It leads to a spindling top with up-curling leaves and terminates as a rule in the death of the affected stems before the tubers are set. It is attributed to bacteria. But little of it was seen in the experimental plots, less than in each of the two moister seasons of 1906 and 1907. The writers have come to expect it chiefly on cool moist soils which are inadequately underdrained. Specimens have been received this year from correspondents in Vermont, Massachusetts, and New York, and have been received also from Canada, showing a general distribution of the malady in the northeastern potato section. Conclusions to date are that the germs are carried on the seed tubers, but that they are not sufficiently virulent to cause serious loss unless soil conditions are especially favorable. This would indicate seed disinfection as the proper remedy in case the trouble is anticipated, using the formalin method outlined above.

ORCHARD DISEASES

No especial work was underway upon orchard or garden crops, and the following brief notes are based upon general observations supplemented by specimens submitted by correspondents.

Apple scab. (*Venturia inaequalis*) was less prevalent and destructive than usual.

The same statement holds for the closely allied *Pear scab* (*Venturia pirina.*)

Apple rust caused by the fungus *Gymnosporangeum macropus* was reported as serious by two correspondents. This causes rusty brown spotting of the apple leaves, which when badly attacked begin to fall in midsummer, thus seriously weakening the tree. The infection comes from the galls on red juniper (cedar apples). The infection may be reduced by spraying the apple foliage in early spring, but this is at best only partially successful, whereas the destruction of the junipers ends the trouble.[1] Since these have slight value for ornament or other purpose it is the part of wisdom to remove them from the neighborhood of apple orchards.

Fire blight. This is the bacterial disease (*Bacillus amylovorus*) which is most destructive on pear, less so on apple, and occasional on plum. Only one orchardist complained of it last year, nor has it been serious for several years. Orchardists may well take advantage of such a period when natural agencies are combining to hold the malady in abeyance. Small effort in the way of pruning will suffice now to eradicate it wholly from any orchard.

Plum scab, due to the fungus *Cladosporium carpophilum* was reported by one correspondent. Early spraying is called for to prevent this malady, beginning promptly after the fruit is set.

GARDEN DISEASES

Only three of these merit special mention.

Blackberry rust. The orange rust of the leaves (*Gymnoconia interstitialis*) was reported by several berry growers. It is common in wild plants and needs to be guarded against in cultivated plantations. Since when once introduced it is perennial in the plant, diseased stools should be promptly uprooted and burned. If detected before the ripening of its spores, no general spraying is called for.

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[1] See Vt. Sta. Rpt. 6. p. 83 (1892).

Pea blight. Specimens of blighting young plants both of garden peas and of sweet peas were received from several correspondents. This is a stem disease similar to if not identical with that reported from Ohio and there attributed to the fungus *Asilcochyta pisi.*[1] No wholly satisfactory remedy has been worked out for this malady but it is at least wise not to replant for several years in soil where the crop has suffered.

Bean anthracnose. This is often called bean rust. It is due to the fungus *Calletotrichum lindemuthianum* which attacks chiefly the pods, causing ulcer-like spots. It becomes a serious matter as soon as bean culture assumes large proportions. Since it is carried in the seed the securing of sound seed from a healthy field is of first importance, although not always practicable. Spraying with bordeaux mixture has proved efficacious.

Witches broom of birch. Specimens of branches of diseased European white birch were received from a nurseryman the latter part of the summer of 1908. These terminated with the bushy, distorted growth known as "witches brooms." Their general appearance led to the suspicion that the trouble is due to the European fungus *Exoascus turgidus,* which has not heretofore been observed in America. Examination revealed no fruiting fungus to enable us to verify this suspicion. The nurseryman was advised to destroy the diseased trees and to watch the balance of his stock for any reappearance of the malady.

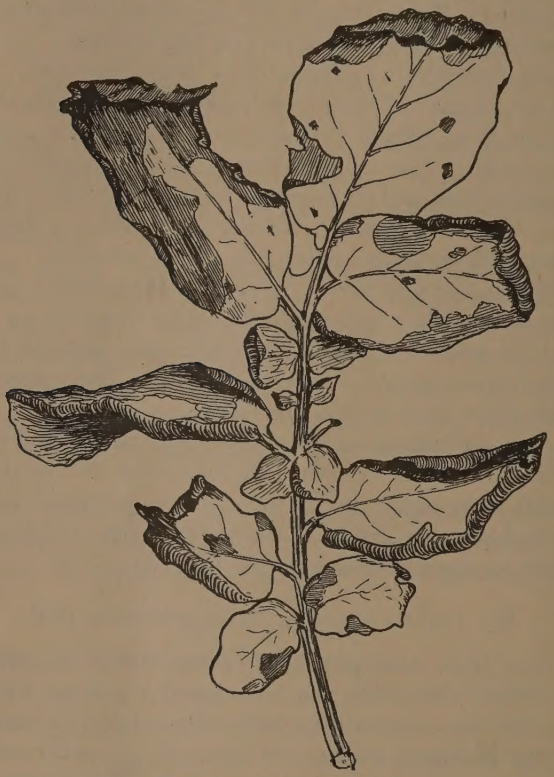
II. POTATO SPRAYING EXPERIMENTS OF 1908

These trials were planned in continuation of the policy to make annual trials of the gain from spraying potatoes with bordeaux mixture; to learn the relative gains, season by season, of sprayings varying in number and date; and to test the merits of any promising new fungicides in comparison with bordeaux mixture.

With these questions in mind sprayings have been made on two fields of potatoes; one a light sandy loam planted May 15

[1] Ohio Sta. Bul. 173. (1906).

with the Green Mountain variety; the other a heavy clay loam where two varieties White Star and Irish Cobbler were included, these having been planted May 21. The soil conditions were fairly uniform in each field and the sprayed plots consisted of three rows each 300 feet long.



Tip burn of potato leaf.

As already explained, there was no late blight or rot in the field and but little early blight. But little of the gain from the spraying is, therefore, due to the fungicidal action of the mixtures in any case. The benefits are rather due to the deterrent

action upon insects and the reduction of tip-burn. This latter gain appears to be associated with the indirect action of the spray mixture, which is probably due in part to its physical relation to the leaf as a light screen, and in part to the chemical action of the copper on the leaf tissue.

Early blight of potato leaf.

The *bordeaux mixture* used consisted of one pound copper sulphate, one pound lime, ten gallons of water, applied at the rate of one hundred and fifty galons per acre in June and July applications and two hundred gallons per acre in August.

The *self-boiled lime-sulphur mixture* consisted of 15 pounds of lime, to which while it was being slacked and boiling hot was added 10 pounds of flours of sulphur. This was then slowly diluted with water to make fifty gallons and was applied at the same rate as the bordeaux mixture.

The *control* rows were kept free from the colorado beetle by dusting them with paris green-lime, consisting of one pound paris green in twenty pounds of air slaked lime, applied at the rate of thirty pounds per acre.

The plots with dates of treatment were as follows:

FIELD A, SANDY LOAM, VARIETY, GREEN MOUNTAIN

Plot 1. Bordeaux-paris green mixture; four times, June 26, July 9, August 5, 26.

Plot. 2. Lime-sulphur mixture; four times, June 26, July 9, August 5, 26. (Supplemented by paris green-lime).

Plot 3. Control; paris green-lime as needed to control the colorado beetle.

Plot 4. Bordeaux-paris green mixture; two times, August 6, 26.

FIELD B, CLAY LOAM

Plot 5. Irish Cobbler. Bordeaux-paris green mixture; four times, July 2, 20, August 6, 25.

Plot 6. Irish Cobbler, (control); paris green-lime as needed to control the colorado beetles.

Plot 7. Irish Cobbler. Lime-sulphur four times; July 2, 20, August 6, 25. (Supplemented by paris green-lime).

Plot 8. White Star. Lime-sulphur four times; July 2, 20, August 6, 25. (Supplemented by paris green lime).

Plot 9. White Star (control) paris green-lime as needed to control the colorado beetles.

Plot 10. White Star. Bordeaux mixture two times; August 8, 26.

The colorado beetles paid so little attention to the presence of the lime-sulphur mixture that it was found necessary to dust

plots 2, 7, and 8 with paris green-lime in order to save them from these insects.

The beneficial effects of the bordeaux mixture as compared with the other treatments became apparent after the second application and increased relatively till the close of the season. One result of the spraying was the lessened amount of tip-burn on these sprayed plots. To secure more exact data as to this matter counts were made on three average hills of each plot of Field A., on August 19 with the following result. The figures indicate the average number of leaflets on each hill that were not affected by tip-burn.

Plot 1 Bordeaux, four times 515
" 2 Unsprayed 95
" 3 Bordeaux, two times 247
" 4 Lime-sulphur 236

From this showing it is evident that the benefits are most marked from four sprayings with bordeaux mixture which gave an average of over five times as many healthy leaflets per hill as the control plants showed.

Since tuber production is directly dependent upon healthy foliage the condition of the leaves is in general a fair index to yield. The above figures were, therefore, in a way prophetic of the yields secured when the crop was harvested in October.

Field A. Sandy loam. Plots 1-4 Green Mountain. Yields in pounds per plot of three rows each 300 feet long.

Plot.	Total.	Large tubers.	Small tubers.	Gain % large tubers.
1. Bordeaux mixture, four times	581	542	39	154
2. Lime-sulphur	324	275	49	29
3. Control (paris green)	253	213	40	..
4. Bordeaux mixture, two times	436	394	42	85

Field B. Clay loam. Plots 5-7 Irish Cobbler; 8-10 White Star. Yields in pounds per plot of three rows each 300 feet long.

Plot.	Total.	Large tubers.	Small tubers.	Gain % large tubers.
5. Bordeaux mixture, four times	283	239	44	128
6. Control (paris green)	138	105	33	..
7. Lime-sulphur, four times	216	172	44	64
8. Lime-sulphur, four times	237	179	58	17
9. Control (paris green)	199	153	46	..
10. Bordeaux mixture, two times	269	227	42	48

As will be seen from these figures there was some gain from the lime-sulphur mixture, averaging 37 percent over the corresponding control plots. As compared with this, however, two sprayings with bordeaux mixture gave a gain of 67 percent or nearly twice as much as the four applications of lime-sulphur, while from four sprayings with bordeaux mixture the gain was 141 percent or nearly four times that from similar sprayings with lime-sulphur. Under the conditions of dry heat that prevailed last summer four sprayings gave distinctly better results than two sprayings.

The following table summarizes the gains from the use of bordeaux mixture on late potatoes for the last 18 years at the Vermont station.

GAINS FROM THE USE OF BORDEAUX MIXTURE ON LATE POTATOES

Planted	Sprayed	Yield per acre		Gain per acre
		Sprayed	Not sprayed	
White Star,				
May —, 1891	Aug. 26, Sept. 8,	313 bu.	248 bu.	65 bu. or 26%
May 20, 1892	July 30, Aug. 13, 25,	291 "	99 "	192 " " 194 "
May 20, 1893	Aug. 1, 16, 29,	338 "	114 "	224 " " 196 "
Apr. 26, 1894	June 16, July 17, Aug. 30,	323 "	251 "	72 " " 29 "
May 20, 1895	July 25, Aug. 13, 31,	389 "	219 "	170 " " 78 "
Polaris,				
May 15, 1896	Aug. 7, 21,	325 "	267 "	68 " " 26 "
June 1, 1897	July 27, Aug. 17, 28,	151 "	80 "	71 " " 89 "
White Star,				
May 10, 1898	July 21, Aug. 10,	238 "	112 "	126 " " 112 "
Average, 3 varieties,				
May 18, 1899	July 26, Aug. 17, Sept. 8,	229 "	161 "	68 " " 42 "
Delaware,				
May 23, 1900	Aug. 4, 23,	285 "	225 "	60 " " 27 "
May 25, 1901	July 20, Aug. 21,	170 "	54 "	116 " " 215 "
May 15, 1902	Aug. 1, 20,	298 "	164 "	134 " " 82 "
Green Mountain,				
May 1, 1903	Aug. 10,	361 "	237 "	124 " " 52 "
Delaware				
May 25, 1904	Aug. 1, Sept. 1,	327 "	193 "	134 " " 69 "
May 15, 1905	Aug. 2, 21,			
Green Mountain,		382 "	221 "	161 " " 73 "
May 27, 1906	Aug. 13, 22,	133 "	101 "	32 " " 32 "
May 1, 1907	July 16, 25, Aug. 8, 22,	171 "	63 "	108 " " 175 "
May 15, 1908	June 26, July 9, Aug. 6, 26,	156 "	65 "	91 " " 140 "
	Average of 18 years,	271 "	159 "	112 " " 92 "

It is hardly necessary to comment further on these figures than to emphasize the following points:

The mixture consists of five pounds copper sulphate, five pounds lime, fifty gallons (one barrel) water, to which is added if needed a half pound paris green in order to combat the colorado beetle.

Spraying should begin while the plants are still healthy and vigorous.

Spraying should be thoroughly done, at least two barrels of the mixture per acre being applied.

If in doubt as to when to begin, start earlier and spray oftener than seems necessary, since an excess of the mixture does no harm.

Bulletin 113 (free for the asking) discusses spraying and gives directions for the preparation and use of many kinds of fungicides and insecticides.